

Drift Chambers: The Science behind the Art

- What are they? how do they work?
- ionization of the gas by particles
- “drifting” of the electrons
- the “avalanche” at the wire
- how tracking works
- frequently asked questions (**your** part!)

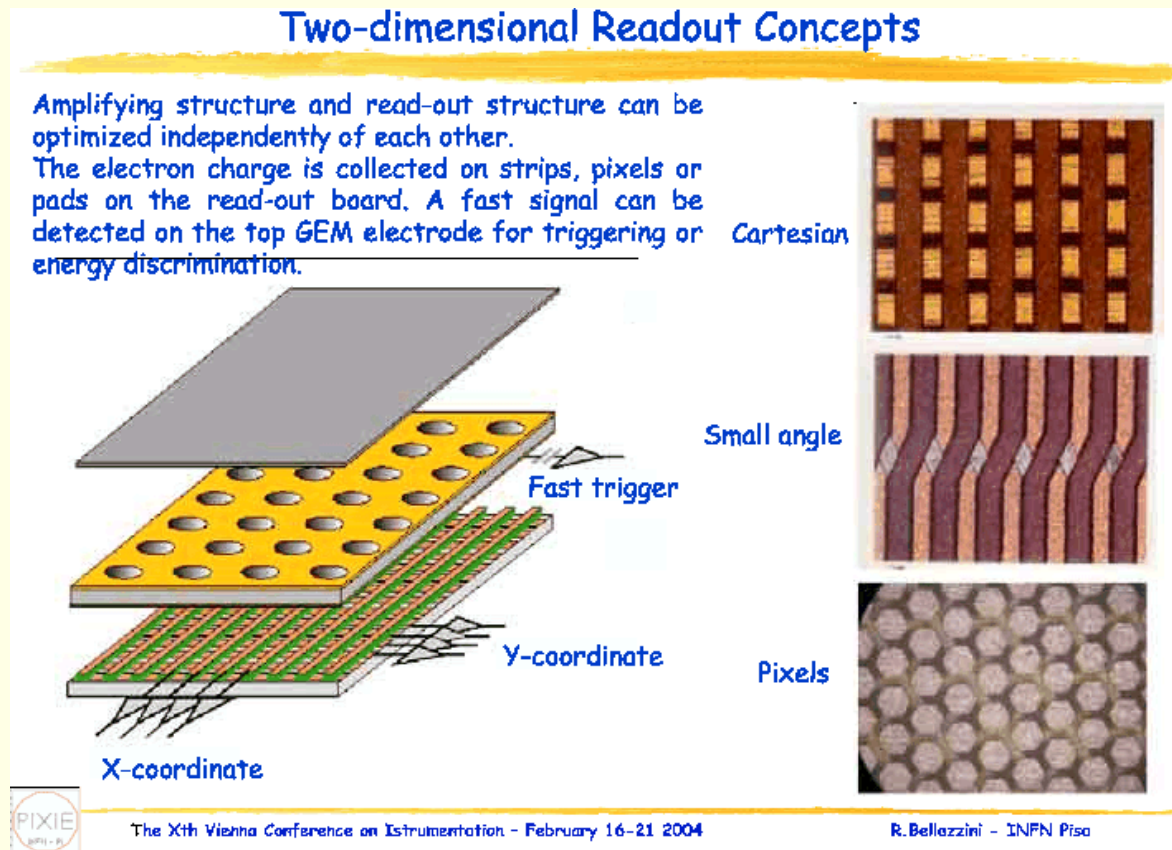
the **motivation** (you get to go to Vienna !)



there are alternatives!

- Micro-pattern gas detectors
 - No wires to break, accurate patterns, fast ion clearing, anode at ground
 - Ideal for TPC's; not as uniform as wires
 - Less multiple scattering than Silicon
 - Multi-GEM's -> less ion feedback
 - more stable at same gain
 - shape of dielectric important
 - Micro-megas w/ resistive anodes
 - > competitive with GEM's
 - Flexible readout schemes !

- Monolithic pixel detectors

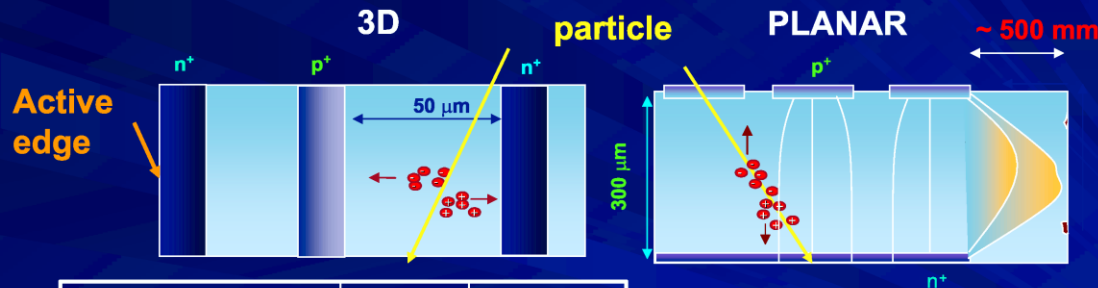


from
Bellazini's
talk

New Types of Silicon Trackers

3-D sensors

- Combine **VLSI** and **MEMS** (Micro Electro Mechanical Systems) technology.
- **Electrodes** processed inside the bulk instead then implanted on surface.
- **The edge** could become electrode! Dead volume at the Edge < 10 microns!



| | 3D | Planar |
|------------------------|--------|----------|
| Q collection path | 50 μm | 300 μm |
| V _{depletion} | <10V | 70 V |
| Edge sensitivity | 10 μm | 500 μm |
| Q Collection time | 1-2 ns | 10-20 ns |

Proposed by Parker, Kenney 1995

- ❖ NIMA 395 (1997) 328
- ❖ IEEE TNS 46 4 (1999) 1224
- ❖ IEEE TNS 48 2 (2001) 189
- ❖ IEEE TNS 48 6 (2001) 2405
- ❖ IEEE TNS 48 5 (2001) 1629
- ❖ CERN Courier, Vol 43, Number 1, Jan 2003

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VIC 2004

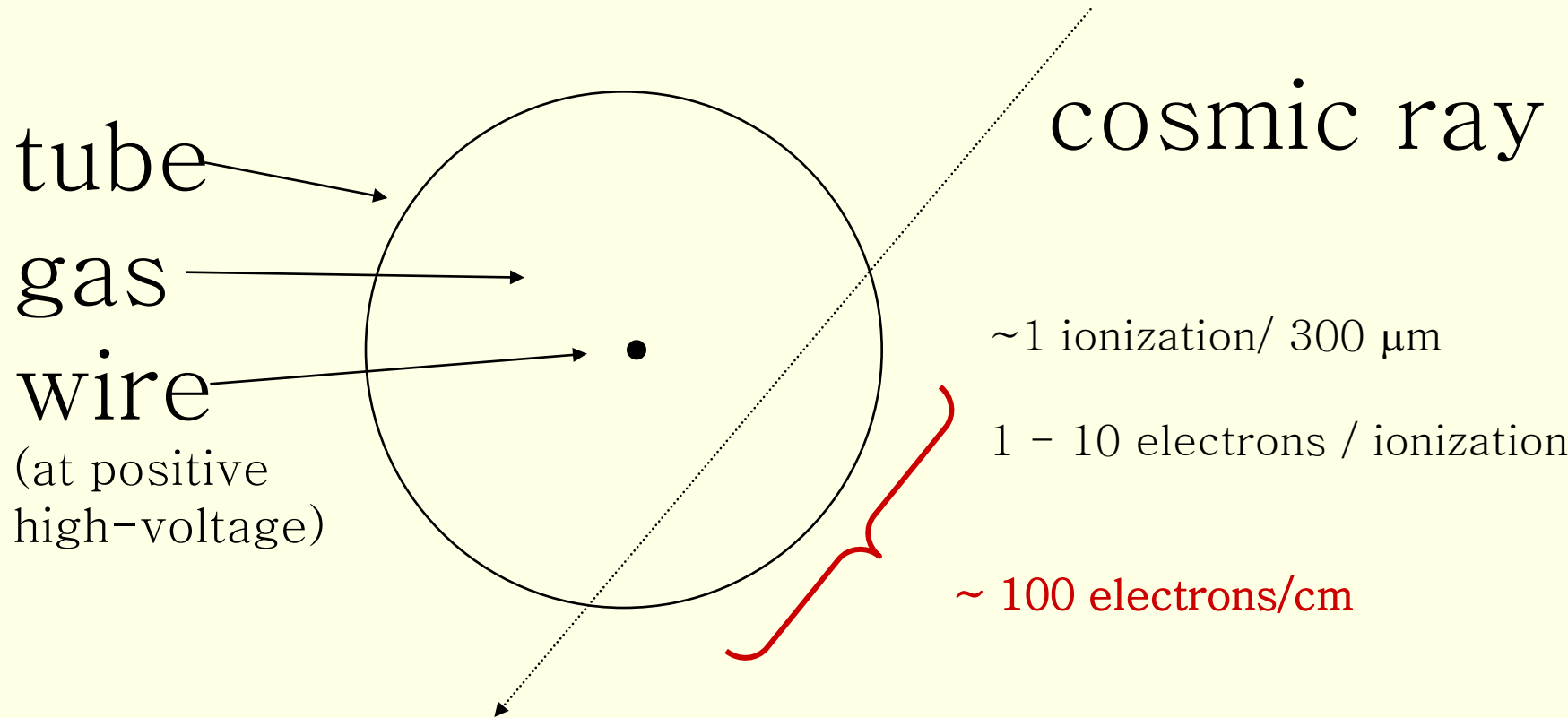
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so why drift chambers ?



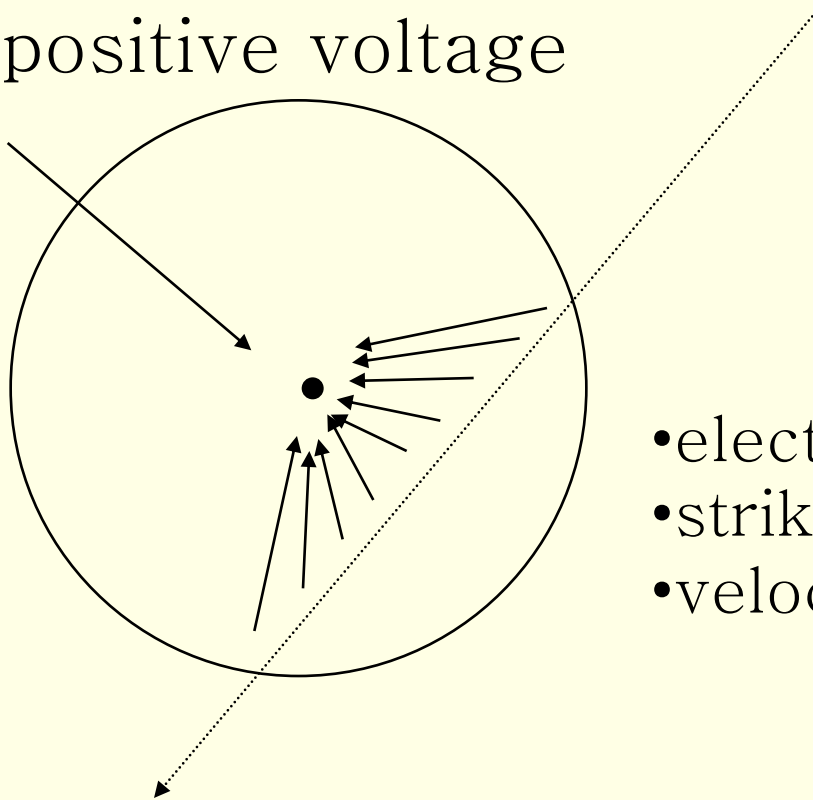
- economical way to cover a large volume with tracking chambers

gas ionization by particles



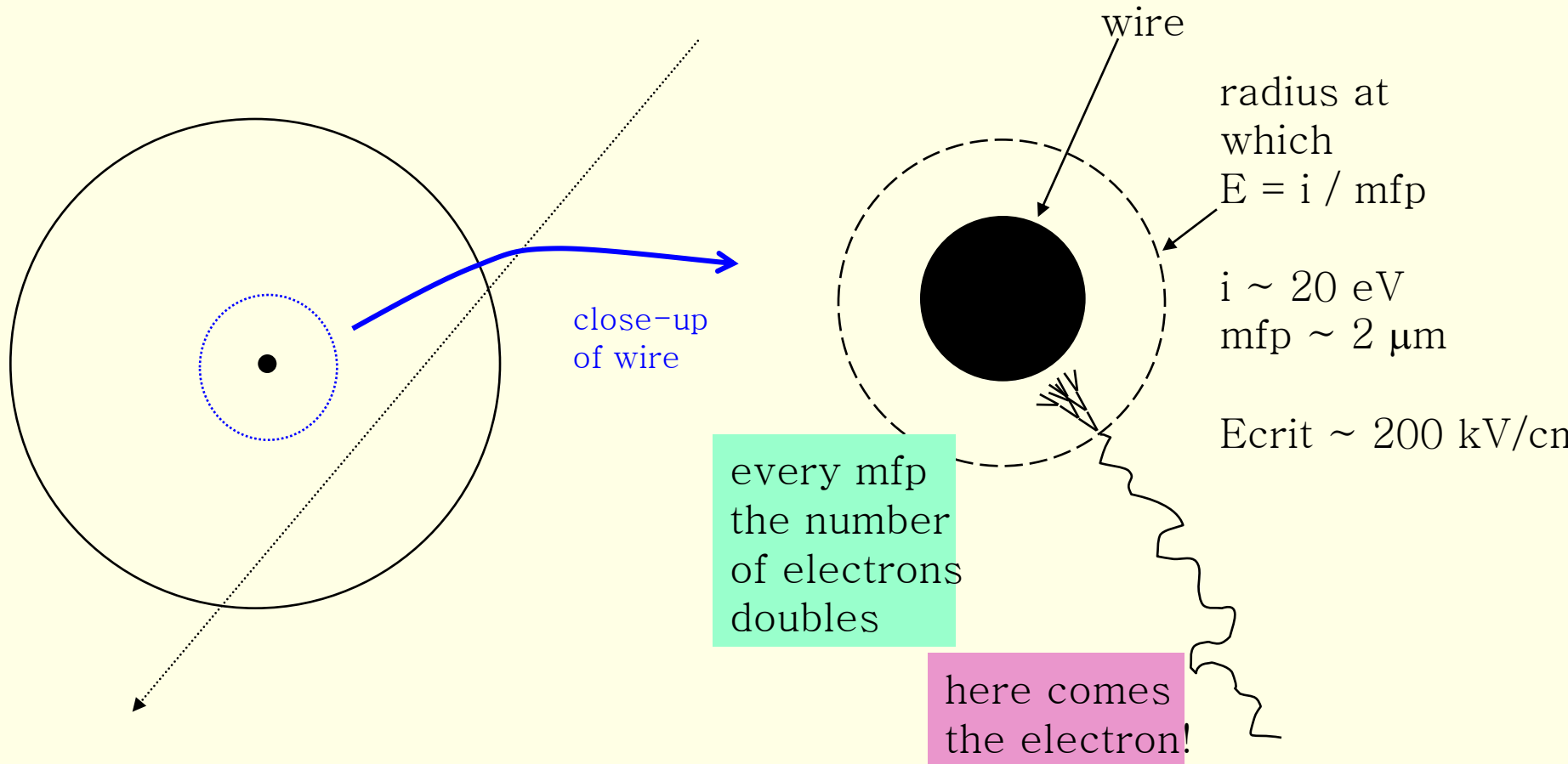
“drifting” of the electrons

wire at positive voltage



- electrons drift to the wire
- strike a molecule every $2\text{ }\mu\text{m}$
- velocity $\sim 50\text{ }\mu\text{m/ns}$ (max)

the “avalanche”



the “avalanche” (cont.)

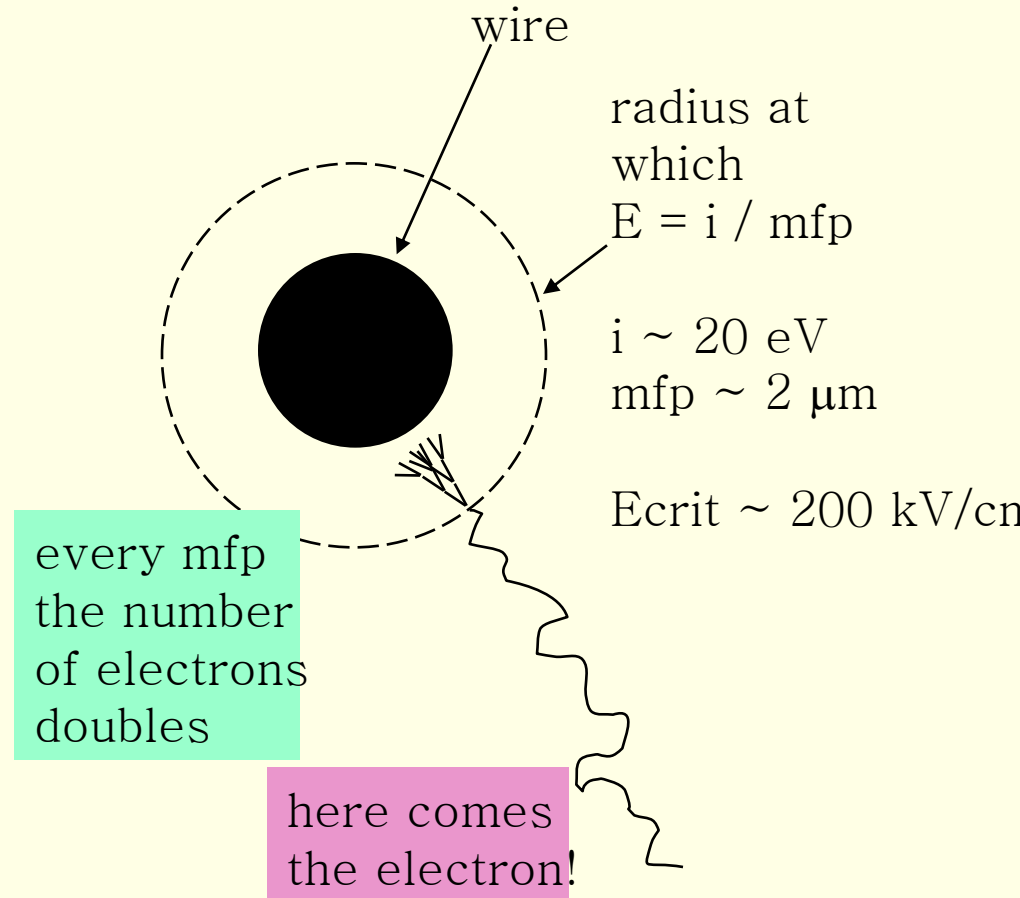
gain $\sim 2^{\text{ndbl}}$

$$\text{ndbl} = (r_{\text{crit}} - r_{\text{wire}}) / \text{mfp}$$

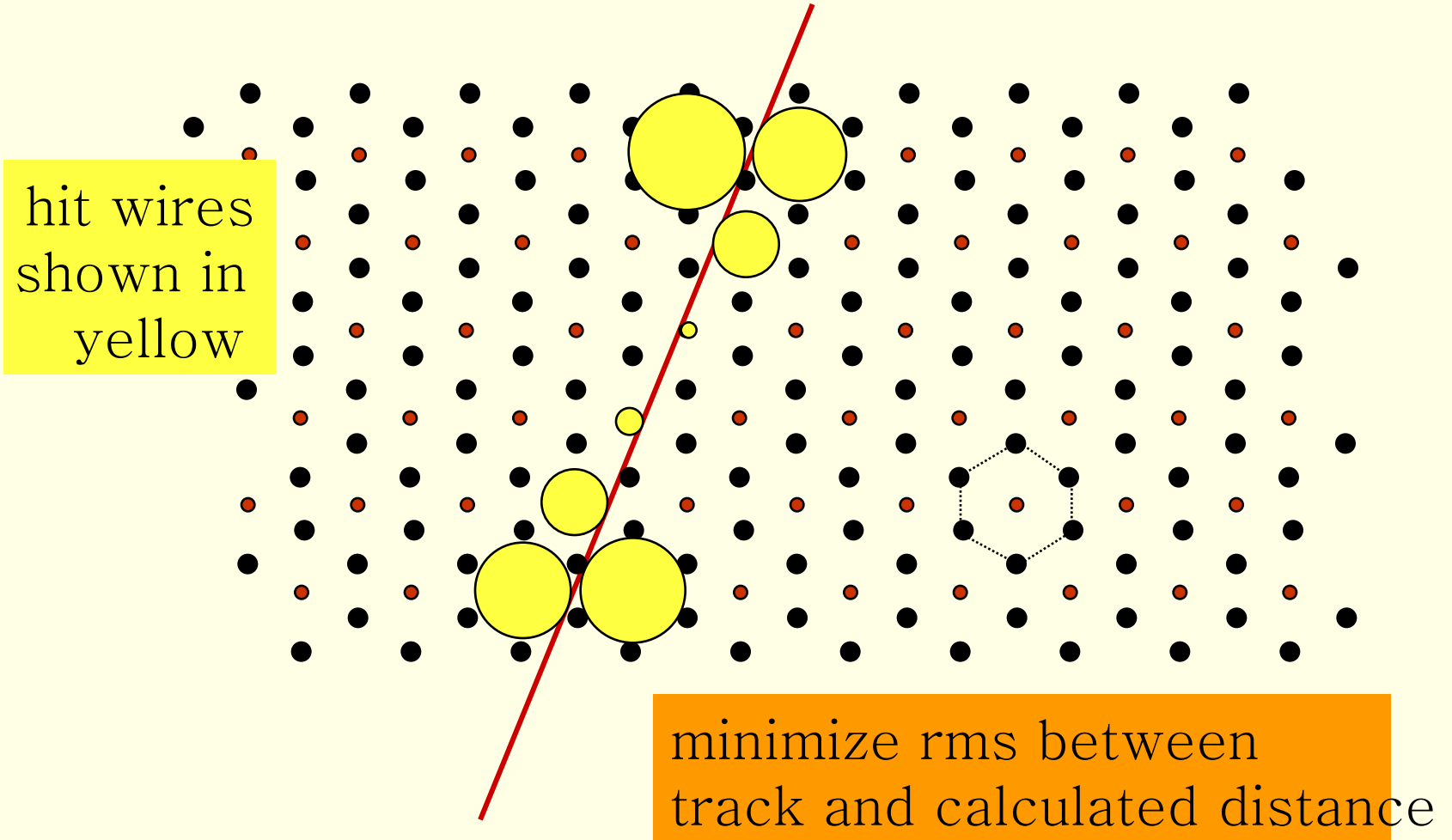
$$E_{\text{crit}} = k * V / r_{\text{crit}}$$

gain $\sim 2^{k*V}$

rule of thumb:
gain doubles every
75 or 100 Volts



how tracking works



Drift Velocity Calculation

20 μm wire
2325 V
88:12 AR:CO₂

30 μm wire
2475 V
92:08 AR:CO₂

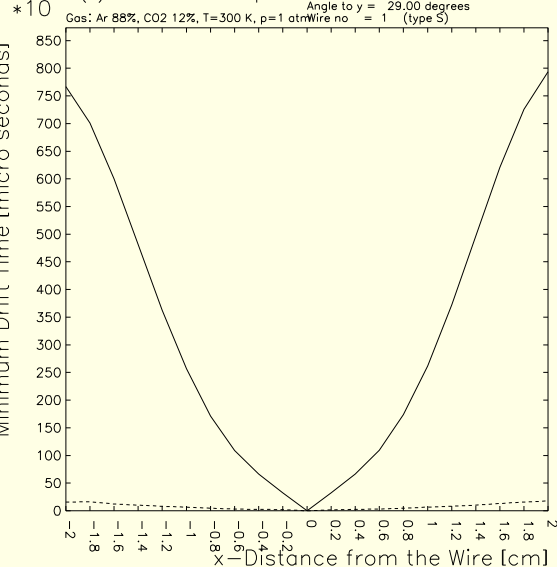
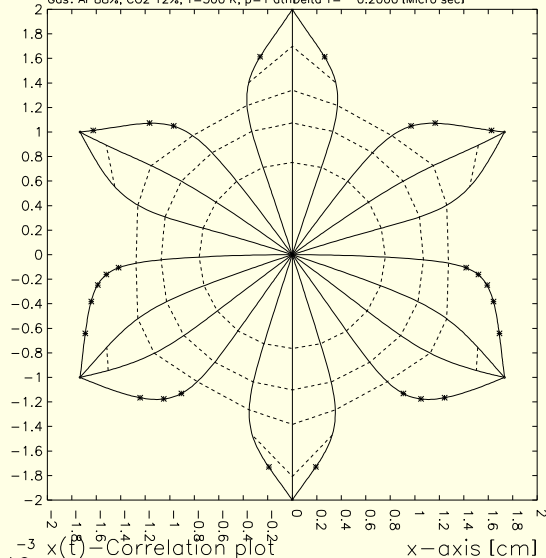
same gain

58% faster

- and more linear !

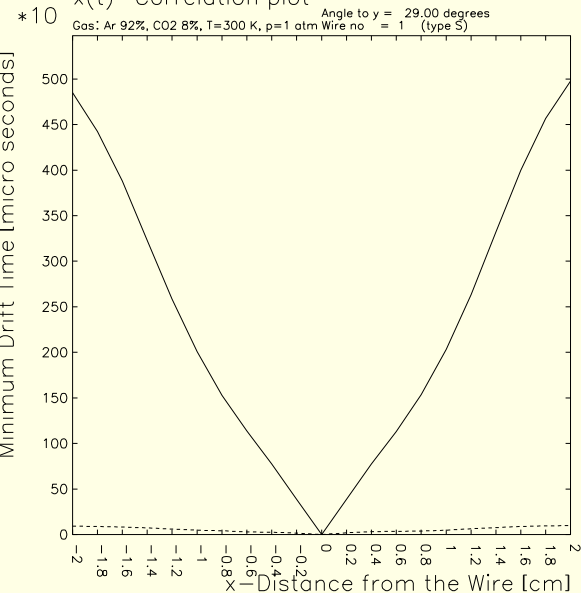
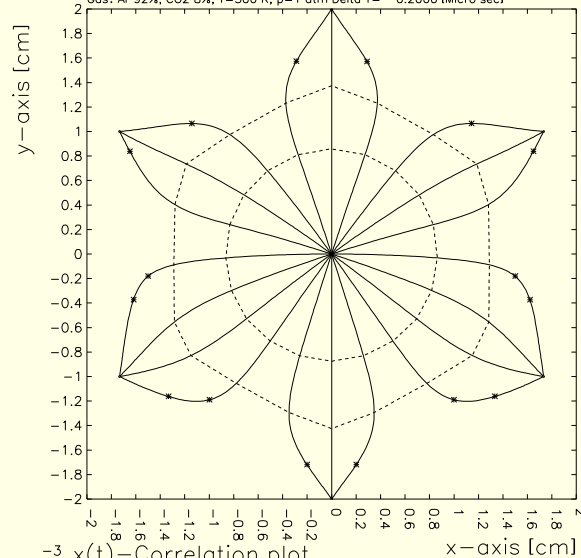
WIRE DRIFT LINE PLOT

Particle ID= Electron
Gas: Ar 88%, CO2 12%, T=300 K, p=1 atm Delta T= 0.2000 (Micro sec)



WIRE DRIFT LINE PLOT

Particle ID= Electron
Gas: Ar 92%, CO2 8%, T=300 K, p=1 atm Delta T= 0.2000 (Micro sec)

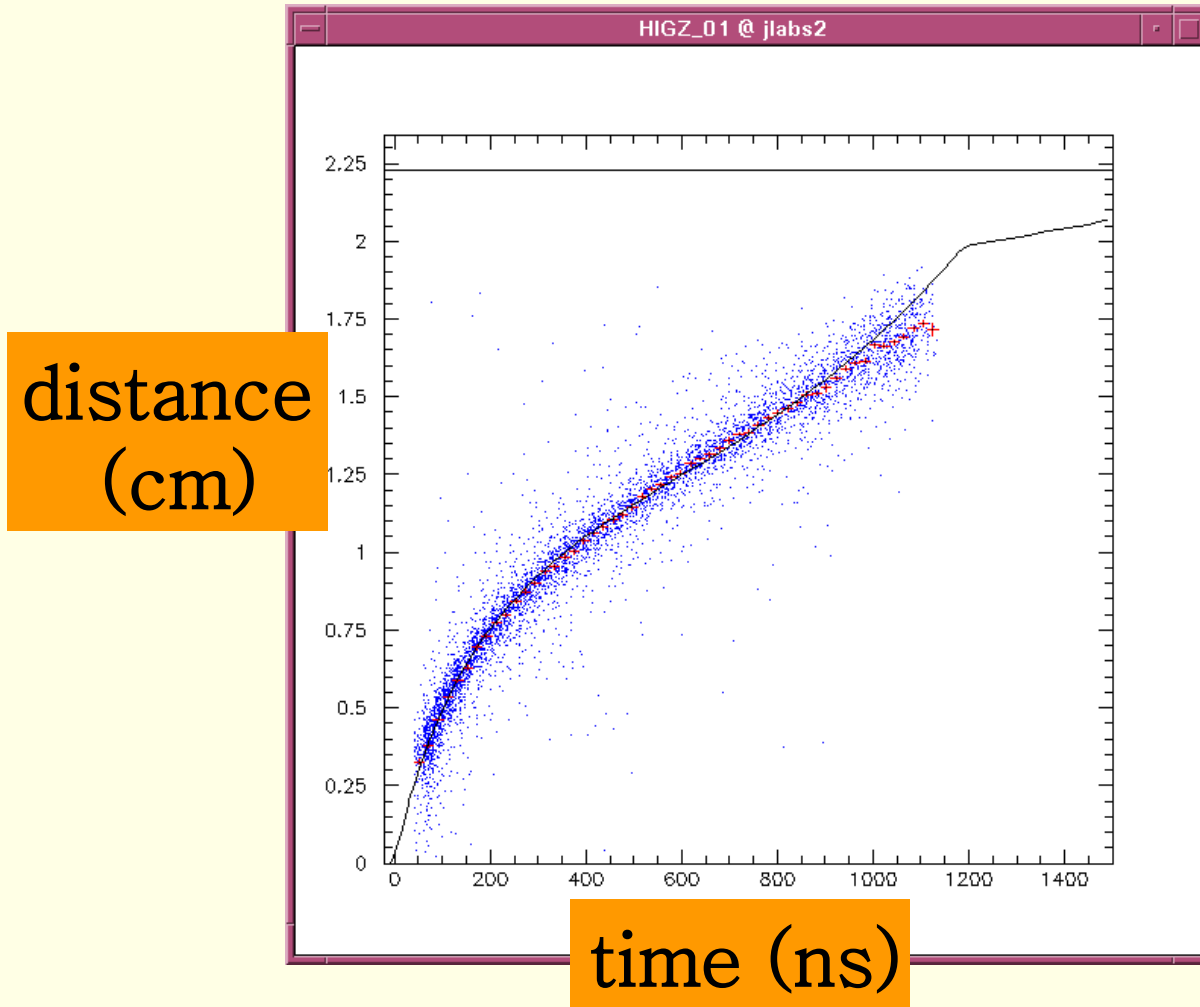


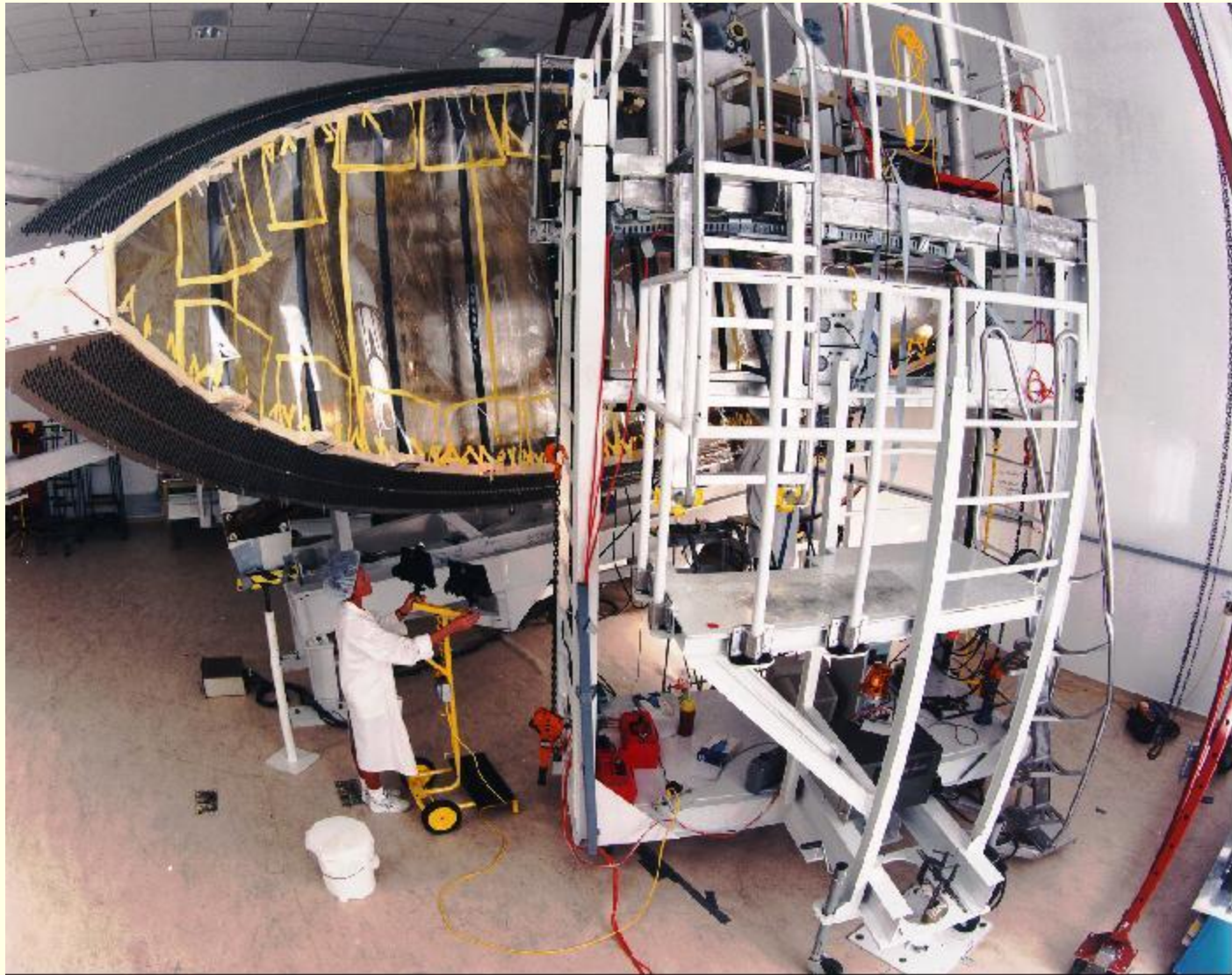
June 5, 2007

What's a Drift Chamber?

Mac Mestayer

drift velocity calibration





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What's a Drift Chamber?

Mac Mestayer

Installing Pre-tensioning Wires

Pre-tensioning

- before we start stringing
- use springs on guard wires
- gradual release of tension



- Operating successfully for ~10 years

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June 5, 2007

What's a Drift Chamber?

Mac Mestayer

FAQ's (your turn!)

drift time calibration

efficiency vs. noise trade-off

magnetic field effects

Malter effect

fast gas

cathode emission

material choices: wires, endplates

quenching gas

reference books

HV plateau